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BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

SUBJECT: Short Stack Static Test Summary
Case 320

DATE: November 21, 1968

FROM: W. C. Brubaker

ABSTRACT

The Apollo Short Stack Static Test (SSST) was successfully completed October 24, 1968. Static and dynamic testing was performed.

A flight configured structure of the SLA/IU/S-IVB Forward Skirt was statically tested as a unit to the ultimate design loads for Max Qα and End Boost flight conditions. The dynamic testing, with vertical and lateral excitation of the LM only, was performed at limit load level for these flight conditions.

Two significant Apollo Program decisions affected the test program: Cork will be applied to the IU for launch vehicles AS-505 and subsequent, and the S-IC end boost acceleration is now limited to 4.0 g (was 4.35 g) for all vehicles. Simulated aerodynamic heating was limited to the S-IVB forward skirt and the end boost testing was cut off at 130% of limit load.

Attached are charts of a summary of test conditions with test completion dates, a comparison of test load levels with AS-501 and AS-502 flight load levels, percent of bending moment contribution to the total running load, and significant end boost data.

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MEMORANDUM FOR FILE

The past three months has been devoted to monitoring the Apollo Short Stack Static Test (SSST). The testing, successfully completed October 24, 1968, was performed by Wyle Laboratories in Huntsville, Alabama.

The SSST was one step in the joint MSC/MSFC program for resolution of the space vehicle oscillation problem. The purpose was to test structures statically and dynamically to prove their capability to support the design loads without failure. This was the first test that employed flight configured structure for the SLA/IU/S-IVB Forward Skirt as a unit. Each unit had been individually tested but with adjacent structures of boilerplate configuration.

Since this was a major test in the Apollo Program this memo summarizes for future reference some of the major test decisions, test observations, and documentation available.

There were initially four steps in the test program. Two flight conditions, Max Qα and End Boost, were to be tested statically to 140% of design limit load (including a static equivalent of AS-501 dynamic loads) and then to 140% of design limit load with vertical and lateral dynamic excitation of the SM and LM. As the test program developed, two intermediate steps were added. Concern for the capability of the IU to withstand without failure the loads and temperature at 140% of End Boost design limit load prompted the additions. The revised sequence was to (1) perform a static test to 1.30 times design limit load for both conditions, (2) load to limit load level for both conditions and dynamically excite the SM and LM, and (3) statically test for both conditions to 1.40 times design limit load.

The sixth step in the revised test program (140% end boost) was eventually deleted as the result of an Apollo Program decision to limit the S-IC end boost acceleration for all vehicles to 4.0 g (was 4.35 g for AS-505 and subsequent).

Prior to the start of end boost testing a decision was made at MSFC to apply cork on the IU for launch vehicles AS-505 and subsequent. On the basis of this decision no simulated aerodynamic heating was applied to the IU during the tests (heat on S-IVB forward skirt only).

During checkout runs for the dynamic tests a Service Module shaker ran away. Quality Control inspection confirmed there was no damage to the test article. However, a concern for capability to maintain complete control of the Service Module shakers prompted MSC to delete them from the program. Vertical and lateral excitation, applied 90° out of phase, was through the LM only.

The writer was an active participant in the test program. Test loads meetings, program status, and test readiness review board meetings were attended. Three of the five tests were witnessed. Suggestions to Wyle and MSC personnel that a step column analysis of the LM loading system and an overall test system balance check be accomplished were accepted and the work performed. The writer prepared and distributed data that compared the loads used in the test with those experienced on flight vehicles AS-501 and AS-502. Test status briefings were given independently to Mr. I. M. Ross and Mr. G. H. Hage.

This was a big program with an optimistic schedule. The scheduled completion date was September 5, 1968. Actual completion was October 24, 1968. Most of the schedule delay was due to problems with the sophisticated computer operation (1600 channels) used for data acquisition and printout. The computer operation did prove to be a very convenient test tool, especially for subcontractors review of data prior to increasing load increments. The usual random hydraulic system leaks existed and one loading pressure bag failed during proof test. It is the writer's opinion that Wyle did a very commendable job on this test program.

Wyle Laboratories reports (initial issue) available from the writer for reference are:

1. Test Procedure No. 56100-1, Test Procedure for Apollo Integrated Shell Static Structural Test Program

2. Technical Memorandum TM 68-10, Data Processing Techniques for Apollo Integrated Shell Static Structural Test Program

3. Quality Assurance Plan for Apollo Integrated Shell Structural Static Test Program (Preliminary).

A list of Wyle specifications, procedures, drawings, etc., applicable to the test is contained in reference 1.

Attached are charts of a summary of test conditions with test completion dates, a comparison of test load levels with AS-501 and AS-502 flight load levels, percent of bending moment contribution to the total running load, and significant end boost data.

Data used for test briefings is retained by the writer.

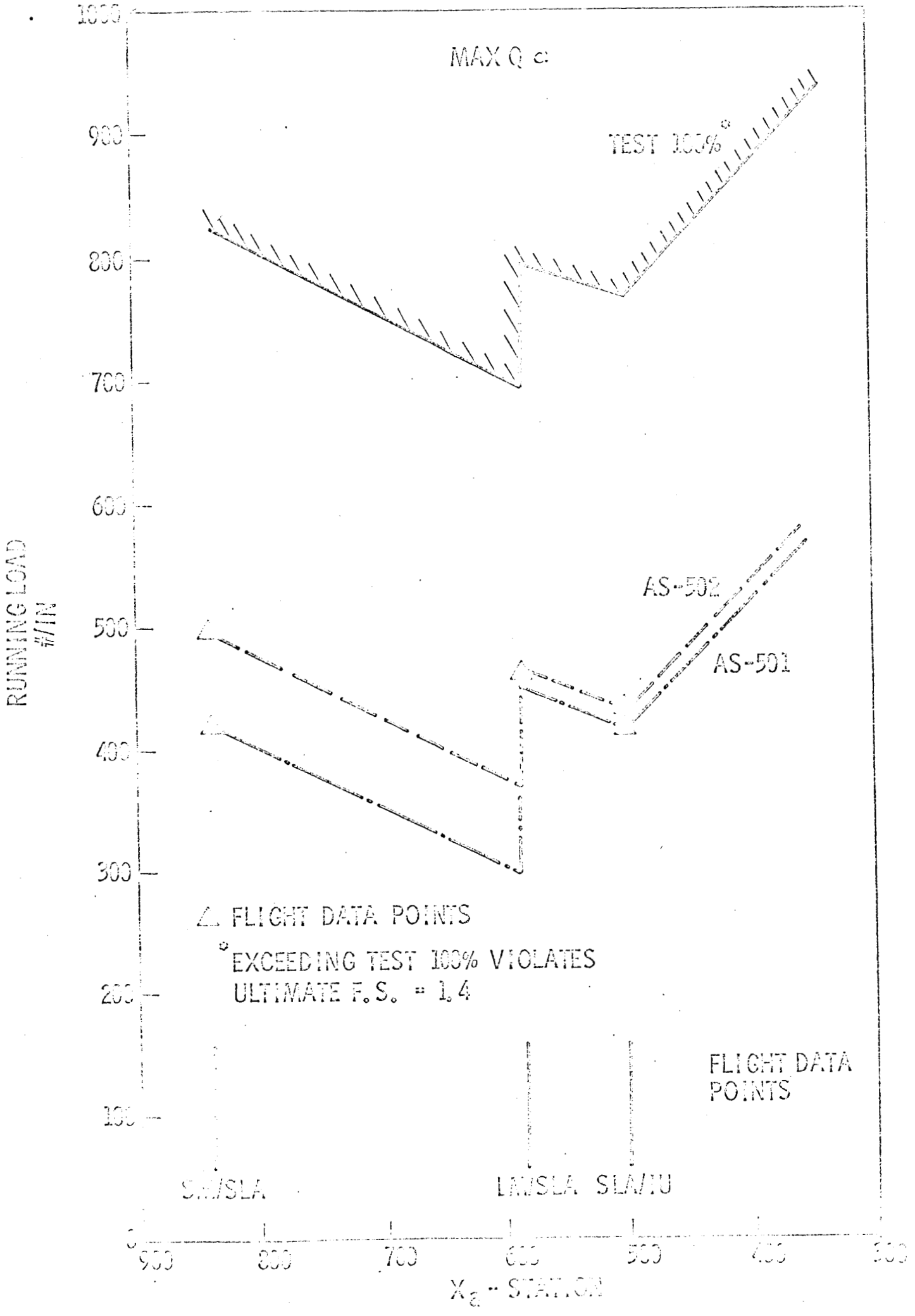
W. C. Brubaker

2031-WCB-sam

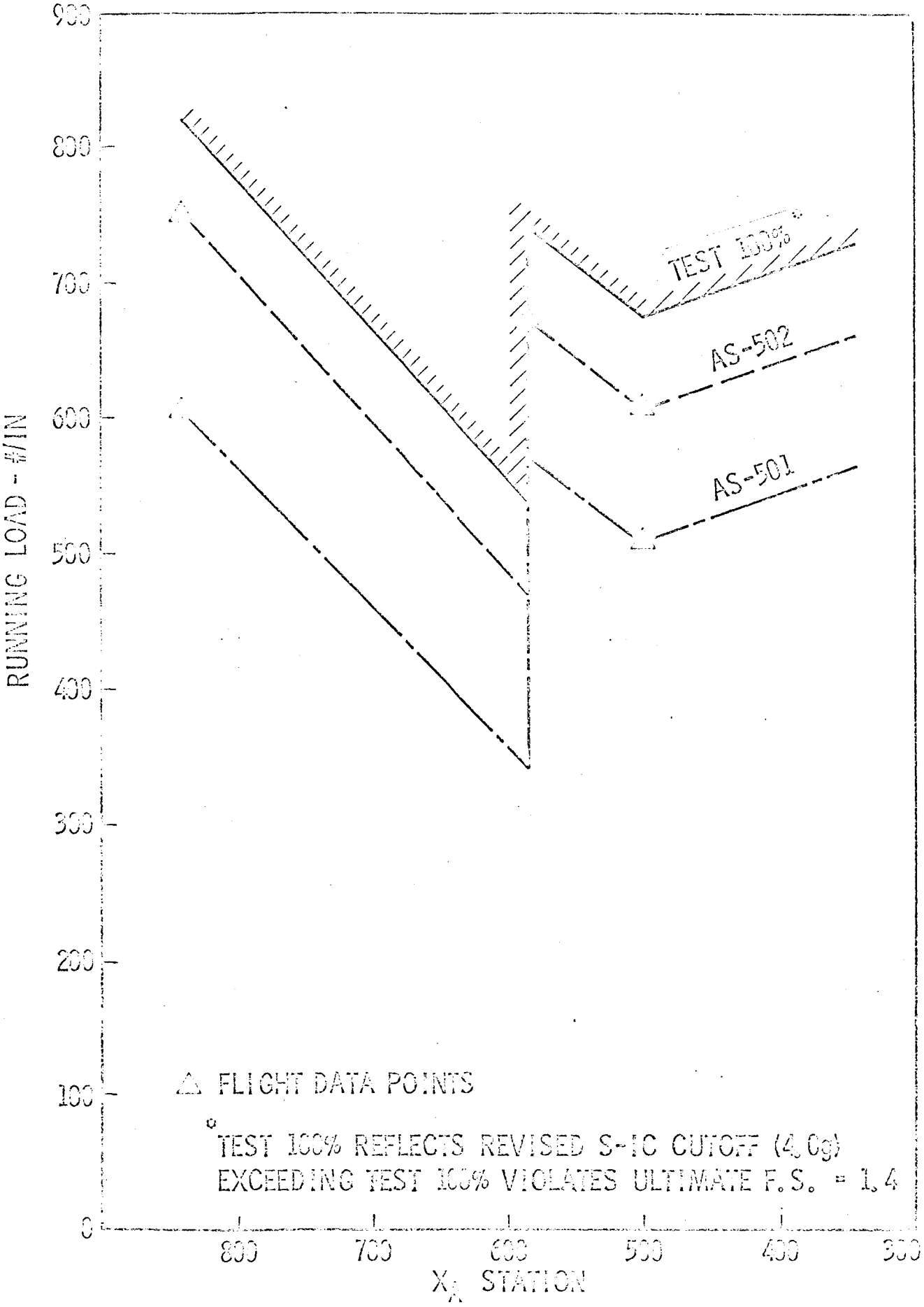
TEST PLAN SUMMARY
SHORT STACK STATIC TEST

TEST NO.	TEST NO.
MAX $q\alpha$, AS - 503	END BOOST, AS - 505
NO TEMP.	S-IVB TEMP.
1	2
STATIC + STATIC EQUIVALENT OF DYNAMIC LOADS	
9/26/68 — 130%	10/4/68
4	3
STATIC + DYNAMIC LOADS	
10/24/68 — 100%	10/18/68
5	6
STATIC + STATIC EQUIVALENT OF DYNAMIC LOADS	
10/24/68 — 140%	DELETED

= COMPLETED


MAX Q c
TEST 100%*
AS-502
AS-501
RUNNING LOAD #/IN
△ FLIGHT DATA POINTS
*EXCEEDING TEST 100% VIOLATES ULTIMATE F.S. = 1.4
FLIGHT DATA POINTS
S-II/SLA
S-IVB/SLA
SLA/IU
X_a - STATION

END BOOST



△ FLIGHT DATA POINTS

*TEST 100% REFLECTS REVISED S-IC CUTOFF (4.0g)
EXCEEDING TEST 100% VIOLATES ULTIMATE F.S. = 1.4

BENDING MOMENT CONTRIBUTION TO RUNNING LOAD

Condition	Static Test	AS502	AS501
Max Q_{α}	53%	25%	17%
End Boost	14-19%	7-14%	7-14%

EMD BOOST DATA

Vehicle	S/C Launch Weight	Axial Accel.	Insertion Weight
AS501	93,681#	4.2 g	84,971#
AS502	94,193#	4.9 g	85,307#
Static Test	≈ 109,000#	4.35 g △	≈ 100,000#

△ NOW LIMITED TO 4.00g BY PROGRAM DECISION.
TEST STOPPED AT 130 % OF DESIGN LIMIT LOAD (USING 4.35g)

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